A Trend Analysis of Polychlorinated Biphenyl (PCB) Contamination in *Micropterus salmoides*, *Ictalurus catus* and *Morone chrysops* sp. in Lake Hartwell, South Carolina

Technical Report #028-82

South Carolina Department of Health and Environmental Control
Bureau of Water Pollution Control
Division of Water Quality Assessment and Enforcement
Biological Services Section
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ABSTRACT

In 1976, the South Carolina Department of Health and Environmental Control and the United States Environmental Protection Agency determined that Lake Hartwell, South Carolina was contaminated with polychlorinated biphenyls (PCBs). From 1977-1981, two to three year old Micropterus salmoides (largemouth bass), Ictalurus catus (white catfish), and Morone chrysops/ sp. (white/hybrid bass) were collected at three Lake Hartwell sample locations (Twelve Mile Creek, Eighteen Mile Creek and Andersonville Island) each spring and analyzed for PCB contamination in edible fish tissue.

Mean concentrations of PCBs in largemouth bass, white catfish and white/hybrid bass composite samples ranged over the four year period from 6.96 to 23.30 ppm, 2.98 to 58.82 ppm and 4.54 to 11.69 ppm, respectively, at Twelve Mile Creek; 0.68 to 2.62 ppm, 0.77 to 8.28 ppm and 2.59 to 6.14 ppm, respectively, at Eighteen Mile Creek; and 0.15 to 0.67 ppm, 0.35 to 0.78 ppm and 0.94 to 6.12 ppm, respectively, at Andersonville Island.

Statistically significant declines in mean PCB concentrations occurred only in white catfish from Twelve Mile Creek and Eighteen Mile Creek and in white/hybrid bass from Andersonville Island since 1977.

INTRODUCTION

In 1975, the Water Supply Division, South Carolina Department of Health and Environmental Control (DHEC) determined that polychlorinated biphenyls (PCBs) were present in the Norris, South Carolina, finished water supply. Subsequent to these findings, DHEC and the United States Environmental Protection Agency (EPA) began a series of physicochemical and biological studies in Pickens and Anderson counties which ultimately led to the discovery that fish in Lake Hartwell were highly contaminated with PCBs. It was further determined that the Sangamo Electric Company, Pickens, South Carolina, was the source of the contamination (Anonymous, 1976; Kinney, 1976).

The contamination was caused by the discharge of PCBs via Sangamo's wastewater treatment plant effluent into Town Creek. The PCBs were primarily used by Sangamo in their power capacitor impregnation area. It was from this area that PCBs reached the wastewater treatment ponds through drainage ditches and stormwater run-off.

Since the level of fish tissue (edible flesh) contamination exceeded the United States Food and Drug Administration (FDA) recommended safe tolerance limit of 5.0 parts per million (ppm), a joint DHEC and EPA public health advisory was issued on August 13, 1976, which warned the public against eating fish taken from Lake Hartwell. The advisory was revised in November 1976, to include only the Seneca River arm of the lake above the South Carolina Highway 24 bridge. This advisory remains in effect.

On August 26, 1976, EPA and DHEC officials met with Sangamo officials to formulate an immediate course of action for controlling the PCB discharge. At this meeting EPA and DHEC learned that Sangamo had already

closed off all areas of the process facility that could cause PCB contamination.

Another meeting was held on October 13, 1976, in which EPA and DHEC directed Sangamo to discontinue the use of PCBs and to limit PCB discharge concentrations to background levels found in their raw water intake. This was to be accomplished by November 1, 1977. Sangamo discontinued using PCBs on June 30, 1977, and their present NPDES permit (#SC0000141) requires a non-detectable (< 1.0 part per billion) discharge limit.

In order to monitor PCB fish tissue levels from a public health perspective and to detect any trends in tissue levels, DHEC and EPA began an intensive fish sampling program in Lake Hartwell in 1976. Since this program began, the fish tissue data have been evaluated on an annual basis to determine if a public health risk continues to exist. Recent data interpretations have indicated that the advisory should remain in effect as PCB levels in fish tissue continue to exceed the FDA 5.0 ppm limit. Although the tissue levels still exceed the 5.0 ppm limit, the data indicate a downward trend in the level of contamination. Since a trend analysis has not been done, the purpose of this report is to statistically evaluate the data to determine if and to what extent trends in PCB fish tissue contamination exist.

BACKGROUND INFORMATION

Polychlorinated biphenyls are chemicals that were first developed in 1929 by Monsanto Company. They are chemically produced by adding chlorine atoms to biphenyl molecules and are identified by the percentage of chlorine added. For example, Aroclor 1248, 1254 and 1260 are names used by Monsanto for PCB compounds having 48 percent, 54 percent and 60 percent chlorine, respectively (Beeton, 1979).

Originally, PCBs were intended for use in sealed environments such as in capacitors and transformers and were ideal for this use due to their stability and heat resisting properties. However, because of their versatility, PCBs had found use in many other products (open systems) such as carbonless paper, paint, plastics, fire retardants, etc., to the extent that they became widespread contaminants in the environment (Buckley, 1975).

The first indication of the prevalence of PCBs in the environment occurred in 1966 when scientists reported that fish in the Baltic Sea were contaminated with PCBs. As a result of this finding, many new studies were begun by other scientists. The results revealed widespread PCB contamination of fish, birds and mammals throughout the world (Buckley, 1975).

In 1969, the public health risks from PCBs became acutely apparent. In western Japan, a team of scientists determined that an epidemic of illnesses (later called Yusho Disease) was caused by the consumption of PCB contaminated rice oil. The illnesses were listed as bronchitis, sensory neuropathy, bursitis, inhibition in growth and abnormal teeth in children, pigmentation of the entire skin of newborn and low birth weights in babies (Kuratsune, et al., 1972).

As a result of these and other scientific findings which documented the persistence and toxicity of PCBs to the environment and the health risks to man, Monsanto voluntarily agreed to stop production of PCBs by 1977 and to deplete its stockpiles by May 1978 (Anonymous, 1976).

By July 2, 1979, the Toxic Substances Control Act (TSCA) prohibited "all manufacture, processing, distribution in commerce, and use of PCBs." Exceptions were made whereby EPA could permit limited use of PCBs so long as they were used in a "totally enclosed manner" or in other uses if the exposure to humans was termed insignificant (40 CFR, Federal Register, 1981).

METHODS

Study Design

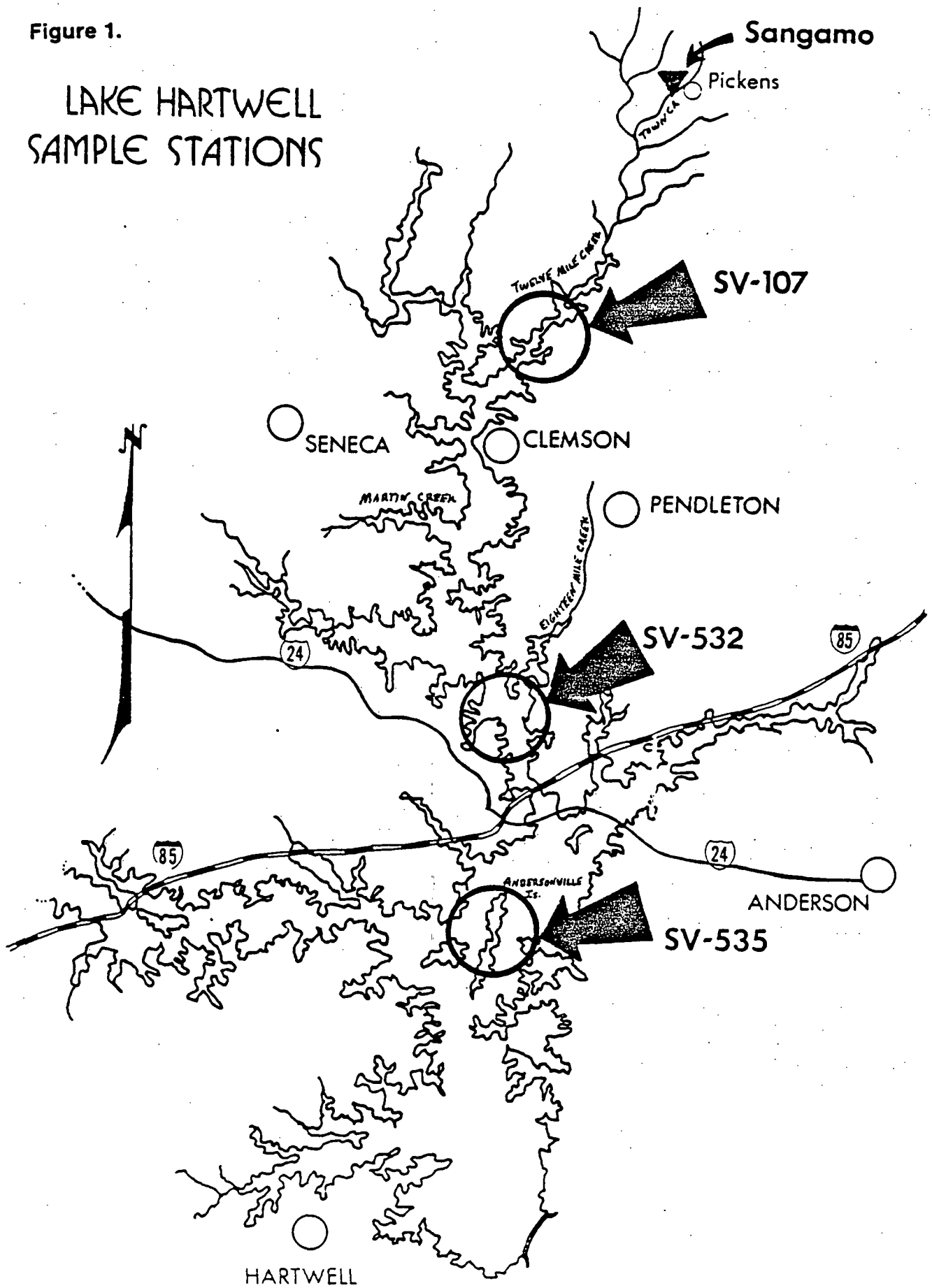
Micropterus salmoides (largemouth bass), *Morone chrysops*/ sp. (white bass/hybrid) and *Ictalurus catus* (white catfish) were selected for study because of their association with sport and/or commercial fisheries and because of their varying migratory and habitat selection characteristics. Largemouth bass are widely distributed predators and sport species that undergo seasonal movements from shallow to deep water and have open-water schooling tendencies in late summer and fall; white bass/ hybrids are schooling pelagic species with populations highly concentrated in tributary arms and streams during spawning periods; and white catfish are benthic omnivores of sport and commercial value.

Collection

During April of each year, 1977-1981, the South Carolina Department of Health and Environmental Control, with the assistance of the U.S. Environmental Protection Agency (Region IV-Ecology Branch) and the S. C. Dept. of Wildlife and Marine Resources, collected largemouth bass, white bass/hybrids and white catfish using electrofishing boats, gill nets and trot lines at three sampling stations in Lake Hartwell (Figure 1). Annually, attempts were made to collect 24 largemouth bass, 24 white bass/hybrids and 24 white catfish in the two to three year size classes of 330-406 mm, 305-508 mm, and 254-356 mm, respectively.

Following collection, individual fish were assigned log numbers and their weights and lengths were recorded. The fish were then filleted, individually wrapped in aluminum foil, labeled and placed on ice. Upon return to the DHEC laboratory, the samples were frozen until shipment to

Figure 1.


LAKE HARTWELL
SAMPLE STATIONS
Sangamo
Pickens
TOWN CR.
TWELVE MILE CREEK
SV-107
SENECA
CLEMSON
MARTIN CREEK
PENDLETON
EIGHTEEN MILE CREEK
SV-532
24
85
85
24
ANDERSONVILLE Is.
ANDERSON
SV-535
HARTWELL

the EPA, Region IV, Surveillance and Analysis Division Laboratory in Athens, Georgia.

Before shipment, all fish were assigned to composite samples, each of which was composed of four similarly sized fish of the same species. Occasionally, two, three or five individual specimens were selected for composite analysis. After the composite samples were identified, the individual fish log numbers were grouped on data sheets. The samples were then placed on ice and delivered by DHEC personnel to the EPA, Region IV laboratory.

Analytical

PCB analyses were conducted by the EPA, Region IV, Surveillance and Analysis Division Laboratory or under EPA contract by the Cooperative Extension Services, University of Georgia, Athens, Georgia. Quality assurance programs were establish and carried out by the EPA laboratory. Although samples were analyzed for Aroclor 1260, 1242, and 1254, Aroclor 1254 was found to be the primary contaminant. In this report, trend analysis is based on the total PCBs found in fish tissue.

The PCB analytical procedure used by the Cooperative Extensive Service is as follows (Bush and Sherer, 1980):

> "The pesticide extraction was conducted according to the FDA Pesticide Analytical Manual Method (Section 211.13f, fish). Approximately 20 gm of diced fish was transferred to a high speed blender and 100 gm of anhydrous Na_2SO_4 added to combine with water and disintegrate the sample. The mixture was alternately blended and mixed with a spatula until Na_2SO_4 and sample were well mixed. Approximately 150 ml of 15% ethyl ether in hexane was added and the mixture blended at high

speed for 2 minutes. The ether-hexane was filtered through a 9 cm Buchner funnel fitted with glass fiber filter paper into a 500 ml suction flask. The residue was reextracted with 2 (100 ml) portions of 15% ether-hexane, blending 2 minutes each time. The extracts were filtered and the combined filtrate evaporated to dryness on a rotary evaporator (50°C) at reduced pressure. The residue was made up to 10 ml with ethyl acetate-toluene (75:25) and the fat removed by gel permeation chromatography (Johnson et. al., AOAC 59:174-189)."

"An automated GPC AutoPrep 1001 equipped with a 25 X 270 mm column containing 40 g of 100 to 200 mesh Bio-Beads SX-3 was used for clean-up of fish tissue and sediment extracts. The GPC was operated under the following conditions: eluting solvent ethyl acetate-toluene (3:1); solvent flow rate - 4.5 ml/min; dump time - 18 min; collection time - 20 min; wash time - 10 min."

"The fraction containing the extract was concentrated on a rotary evaporator and made to a volume of 2 or 5 ml with iso-octane for gas chromatographic analysis."

"Gas liquid chromatographic (GLC) analysis of the non-ionic chlorinated pesticides and PCBs was conducted with a Tracor Model 220 Gas Chromatograph which is equipped with a ^{63}Ni electron capture detector meeting AOAC 29.018 sensitivity requirements. Operating conditions used are as follows: column - 3% OV-1 on Chromsorb W (100-200 mesh); column temperature - 200°C; carrier flow rate - 70-80 cc/min; detector temperature - 250°C. Component identity of signi-

ficant residues was further checked by GLC under the following conditions; 1.5% OV-17, 195% OV-210 on Chromsorb W (100-200 mesh); column temperature - 200°C; carrier flow rate - 70-80 cc/min; detector temperature - 230°C."

"The levels of PCBs and other pesticides were determined by comparison of peak height of sample chromatograms to those of an analytical standard. The component co-chromatographing with DDE is ignored. Concentrations of the compounds were listed as either parts per million (ppm) or parts per billion (ppb). All concentrations were reported on a whole body, wet weight basis."

Trend Analysis

In order to determine yearly trends of PCB contamination in fish, it is imperative that the same size and species of fish be evaluated each year since different sizes as well as species of fish vary in PCB accumulation rates. For this reason, efforts were made to collect 24 fish of the same three species of the same size class each year. This, however, proved to be a more difficult task than first perceived when the study was designed and implemented. Consequently, samples that would have enabled analysis of three sets of six composites made up of four similarly sized specimens of each species, per station, per year were not obtained. Therefore, the trend analysis in this report sometimes involves less than the desired total number of composites.

At sample station SV-535, (Figure 1), largemouth bass were virtually unavailable in 1979 and 1980, consequently, a more abundant species in this portion of the lake, coosae bass (Micropterus coosae), was sub-

stituted. Since coosae bass of a similar age are smaller than largemouth bass, they cannot be grouped by length with largemouth bass and represent the same year class. Therefore, the size range for these two species was widened (250-406mm) and they were grouped together in order to provide some type of trend analysis at SV-535.

The original study design called for white bass in the 305 to 356 mm size class. This size class range was extended from 305 to 508 mm so that hybrids could be included with the white bass, for it has been determined that two-three year old hybrids can reach 508 mm in length (Williams, 1982). There were three reasons for this change. First, during some collections white bass were generally unavailable and were substituted with hybrids. Second, it is suspected that in the earlier collections, whites and hybrids may have been misidentified since their body features are very similar, especially in a 305 to 356 size class range. Third, since both whites and hybrids are of similar genetic type and have similar feeding and migratory habits, it was concluded, for the purpose of this study, that their bioaccumulation rates were similar.

The best way to have conducted this study would have been to look at 24 individual fish rather than six composites per species at each station. This would have given a definitive PCB value for each fish. However, due to the magnitude of this study, it was not economically feasible to analyze individual fish and, therefore, the only alternative was to analyze composites. The resultant PCB value was viewed to be representative of the average concentrations per fish in the composite.

Care was taken to classify specimens of similar lengths and weights so that large fish were not mixed with smaller fish. Since there were four fish per composite (sometimes two, three or five) and only one PCB

value, the lengths and weights were averaged to correspond to the PCB value. These average lengths, weights, and corresponding PCB values were then averaged to represent the annual total average lengths, weights, and PCB concentrations by station for each species (Tables 1-3).

RESULTS AND DISCUSSION

Twelve Mile Creek (SV-107)

Mean concentrations of total PCBs during 1977-1981 ranged from 2.98 to 58.82 ppm in white catfish, 6.96 to 23.30 ppm in largemouth bass and 4.54 to 11.69 ppm in white/hybrid bass (Table I). A plot of mean PCB concentration in white catfish versus year of collection (Figure 2) suggests a downward trend in fish tissue contamination during the five years of sampling. Statistical analyses using analysis of variance (ANOVA) (Duncan et al., 1977) show that there is a significant difference in mean PCBs between the five sampling years (P=.0001). Statistical analysis using Duncan's Multiple Range Test (Steel and Torrie, 1960) shows this difference to be a downward trend from 1977 to 1979. No significant trend is indicated from 1979 through 1981.

Visual observation of the plots of mean PCB concentrations versus year of collection with the largemouth and white/hybrid bass (Figure 2) does not indicate any downward trends except for perhaps the 1980 and 1981 white/hybrid samples. A student's pooled T-Test (Duncan et al., 1977) shows that the decline between 1980 and 1981 is significant (P = .025). Since the number of composite samples analyzed for these two years was similar (7 and 5, respectively), a downward trend in PCB contamination for this species may be indicated.

Eighteen Mile Creek (SV-532)

During 1977-1981 mean concentrations of total PCBs ranged from 0.77 to 8.23 ppm in white catfish 0.68 to 2.62 ppm in largemouth bass and 2.59 to 6.14 ppm in white/hybrid bass (Table 2). A plot of mean PCB

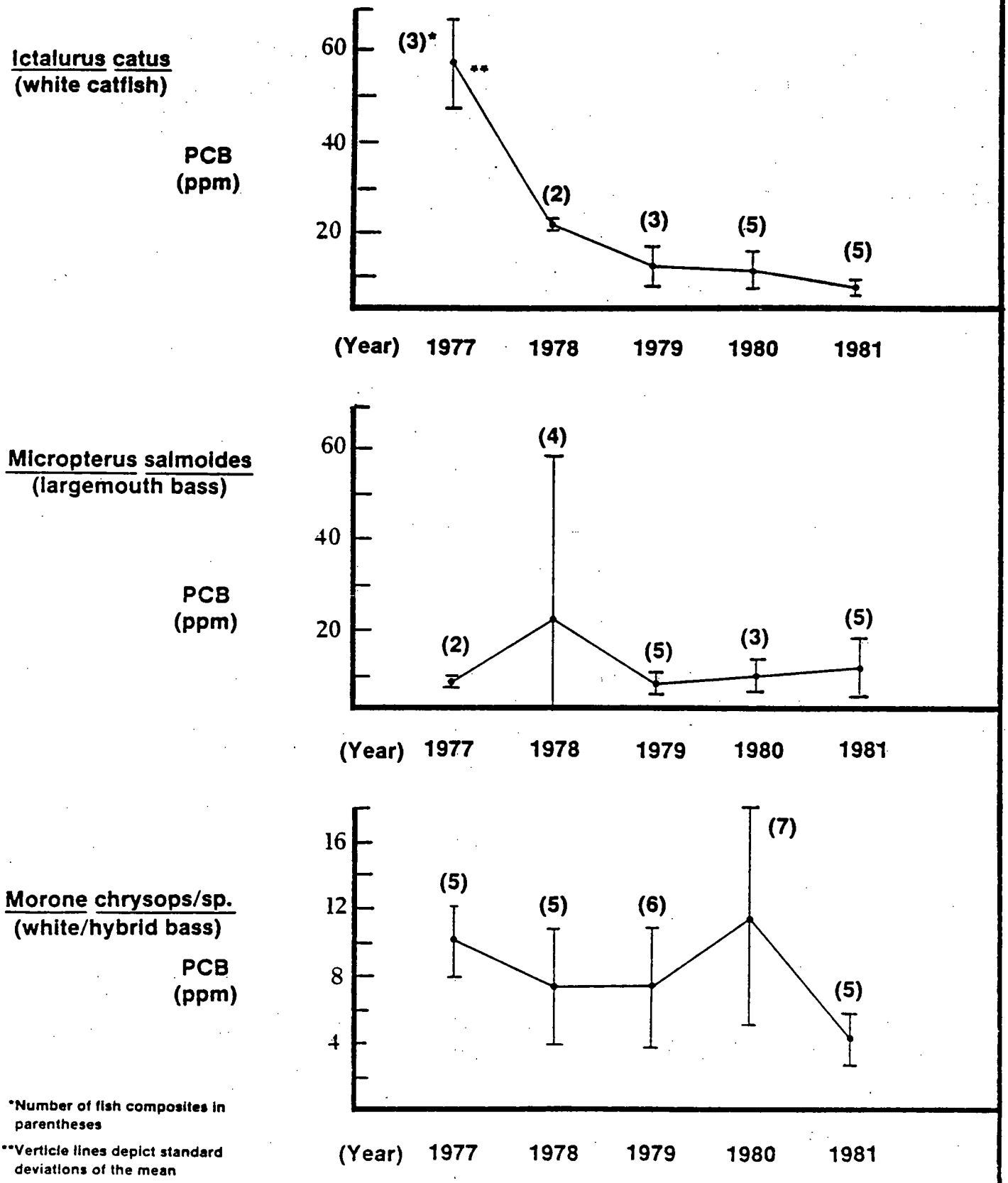
Table 1. Mean concentrations of PCBs in spring (April) collections of Lake Hartwell Ictalurus catus, Morone chrysops/sp. and Micropterus salmoides taken from Twelve Mile Creek (SV-107), Pickens County

Species and Year	Number of Fish	Mean Composite Length	Mean Composte Weight	Range of Total PCBs of Composites	Mean Total PCBs(ppm) of Composites
Ictalurus catus (254-356mm)					
1977	11(3)*	300	368	47.38-66.76	58.82
1978	5(2)	288	304	22.58-23.72	23.15
1979	14(3)	313	423	4.85-14.54	8.44
1980	20(5)	304	387	3.78.14.40	7.48
1981	19(5)	304	396	0.92-04.96	2.98
Micropterus salmoides (330-406mm)					
1977	8(2)	352	859	7.81-09.20	8.51
1978	16(4)	364	652	1.92-74.54	23.30
1979	17(5)	350	572	2.18-10.13	6.96
1980	7(3)	361	664	5.70-11.80	9.00
1981	20(5)	360	652	1.88-19.50	8.66
Morone chrysops/sp. (305-508mm)					
1977	20(5)	355	528	8.18-12.93	9.97
1978	20(5)	345	528	1.81-09.86	7.46
1979	24(6)	337	503	2.23-12.83	7.49
1980	25(7)	329	468	3.83-23.60	11.69
1981	20(5)	321	462	2.42-06.23	4.54

*Number of composite samples given in parentheses

Figure 2.

Mean concentrations of PCBs in Ictalurus catus, Morone chrysops/sp., and Micropterus salmoides composites taken from Twelve Mile Creek (SV-107)



*Number of fish composites in parentheses

**Verticle lines depict standard deviations of the mean

Table 2. Mean concentration of PCBs in spring (April) collections of Lake Hartwell Ictalurus catus, Morone chrysops/sp. and Micropterus salmoides taken from Eighteen Mile Creek (SV-532), Pickens County

Species and Year	Number of Fish	Mean Composite Length	Mean Composite Weight	Range of Total PCBs of Composites	Mean Total PCBs (ppm) of Composites
Ictalurus catus (254-356mm)					
1977	23(6)*	295	260	3.75-10.93	8.28
1978	17(4)	300	310	3.79-11.78	7.06
1979	24(6)	307	354	0.20-23.50	6.51
1980	22(7)	289	284	1.66-03.40	2.38
1981	24(6)	308	326	0.51-01.16	0.77
Micropterus salmoides (330-406mm)					
1977	20(5)	355	591	0.79-1.75	1.28
1978	7(2)	350	580	0.64-1.75	1.20
1979	20(6)	343	479	1.71-3.78	2.62
1980	9(3)	365	568	0.38-0.85	0.68
1981	8(2)	338	510	0.76-1.08	0.92
Morone chrysops/sp. (305-508mm)					
1977	14(4)	384	733	5.13-05.77	5.33
1978	28(7)	359	711	2.30-22.02	6.14
1979	20(5)	334	464	1.99-10.33	4.25
1980	28(7)	373	753	1.95-06.70	3.87
1981	23(6)	320	432	0.83-05.12	2.59

*Number of composite samples given in parentheses

concentrations in white catfish versus year (Figure 3) indicates a similar trend as seen at SV-107. The ANOVA shows a significant difference between years (P=.0263) although not as great as SV-107 (P=.0001). The Duncan's Multiple Range Test shows a significant downward trend from 1977 as compared to 1980 and 1981 and a significant downward trend between 1980 and 1981.

The plot for white/hybrid bass (Figure 3) indicates a slight downward trend but the ANOVA showed no significant difference between years (P=.566). The largemouth bass plot (Figure 3) shows PCB values fluctuating in an up and down manner, therefore, no trend is indicated.

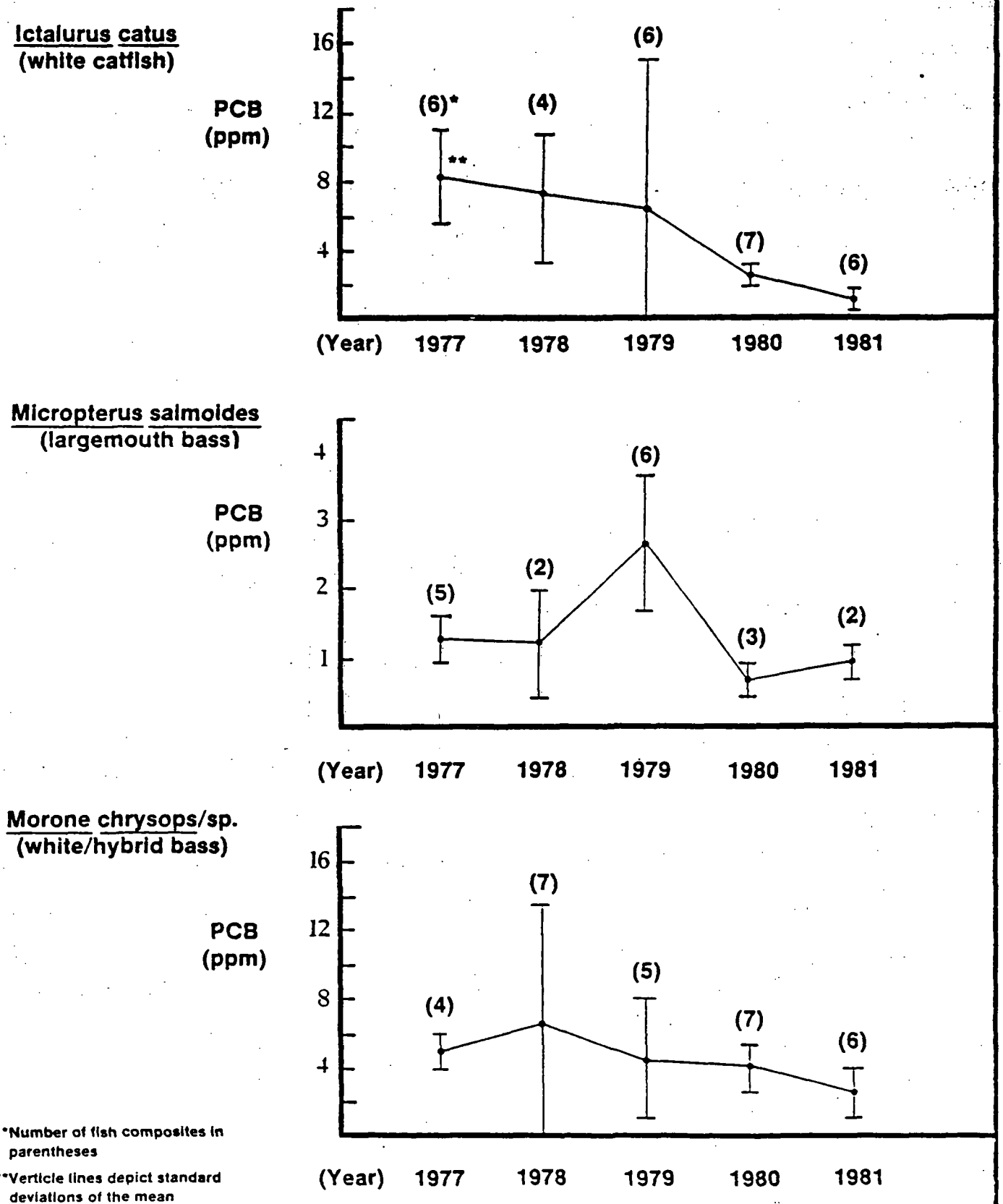
Andersonville Island (SV-535)

Mean concentrations of total PCBs during 1977-1981 ranged from 0.35 to 0.78 ppm for white catfish, 0.15 to 0.67 ppm for largemouth/ coosae bass and 0.94 to 6.12 ppm for white/hybrid bass (Table 3). A plot of mean PCB concentrations in white/hybrid bass versus year indicates a downward trend (Figure 4). The ANOVA indicates a significant difference between sampling years (P=.0001). However, the Duncan's Multiple Range Test indicates this difference only separates 1977 from the rest. Years 1978 to 1981 show no significant difference and, therefore, no apparent downward trend since 1978.

The plots for the white catfish and largemouth/coosae bass (Figure 4) show only moderate declines over the sampling years, therefore, no significant trend is indicated. The important consideration at this station is that the PCB concentrations in both the largemouth/ coosae bass and white catfish have been less than 1.25 ppm since sampling began in 1977. Since composites of four fish are being analyzed and not

Figure 3.

Mean concentrations of PCBs in Ictalurus catus, Morone chrysops/sp. and Micropterus salmoides composites taken from Eighteen Mile Creek (SV-532)



*Number of fish composites in parentheses

**Verticle lines depict standard deviations of the mean

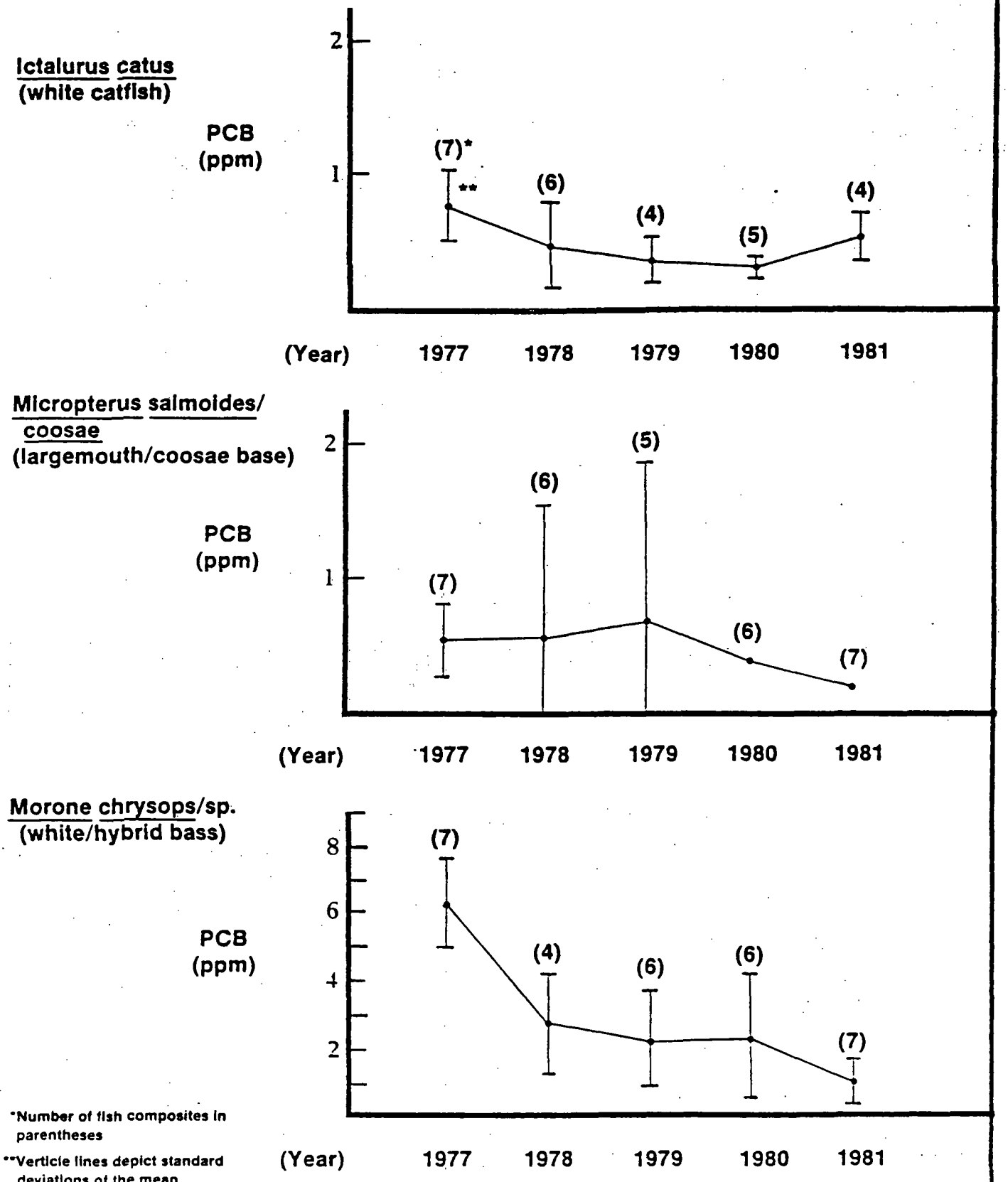
Table 3. Mean concentrations of PCBs in spring (April) collections of Lake Hartwell Ictalurus catus, Morone chrysops/sp. and Micropterus salmoides/coosae taken from Andersonville Island (SV-535), Anderson County

Species and Year	Number of Fish	Mean Composite Length	Mean Composite Weight	Range of Total PCBs of Composites	Mean Total of PCBs (ppm) of Composites
Ictalurus catus (254-356mm)					
1977	28(7)*	294	269	0.60 - 1.33	0.78
1978	24(6)	298	292	0.00 - 0.87	0.43
1979	17(4)	300	274	0.22 - 0.54	0.37
1980	19(5)	285	253	0.30 - 0.41	0.35
1981	14(4)	309	329	0.36 - 0.71	0.51
Micropterus salmoides/coosae (250-406mm)					
1977	25(7)(salmoides)	270	430	0.41 - 0.92	0.60
1978	23(6)(salmoides)	294	312	0.13 - 2.07	0.59
1979	22(5)(coosae)	302	356	0.11 - 2.46	0.67
1980	23(6)(coosae)	279	261	0.00 - 0.30	0.30
1981	24(7)(salmoides and coosae)	307	372	0.11 - 0.20	0.15
Morone chrysops/sp. (305-508mm)					
1977	26(7)	420	1058	4.08 - 8.27	6.12
1978	11(4)	385	803	1.26 - 4.13	2.73
1979	23(6)	405	950	0.57 - 4.17	2.23
1980	22(6)	391	863	0.87 - 5.90	2.26
1981	25(7)	359	609	0.35 - 2.16	0.94

* Number of composite samples given in parentheses

Figure 4.

Mean concentrations of PCBs in Ictalurus catus, Morone chrysops/sp., and Micropterus salmoides /coosae composites taken from Andersonville Island (SV-535)



*Number of fish composites in parentheses

**Verticle lines depict standard deviations of the mean

individual fish, a total composite PCB value of less than 1.25 ppm is necessary to assure that no single fish has a PCB level above the FDA recommended safe tolerance limit of 5.0 ppm.

CONCLUSIONS

Since 1977, there has been a reduction in PCB contamination of two to three year size class white catfish (254-356 mm) in Twelve Mile Creek (SV-107) and Eighteen Mile Creek (SV-532) of Lake Hartwell. It is also concluded that there has been a PCB reduction in two to three year size class white/hybrid bass from Andersonville Island (SV-535). Only the white catfish from SV-107 indicate a significant downward trend over consecutive years (1977-1979). The white catfish from SV-532 showed a significant yearly decline between 1977 as compared to 1980 and 1981 and a significant decline between 1980 and 1981. The white/ hybrid bass from SV-535 showed a significant reduction only between 1977 and 1978. Since there were PCB declines at all stations between 1977 and other years, it appears that steps taken in late 1976 to control and/or eliminate PCB discharges to Lake Hartwell had an immediate effect on PCB reduction in fish flesh.

RECOMMENDATIONS

It is recommended that the present advisory against eating fish taken from Lake Hartwell in the Seneca River arm of the lake above U.S. Highway 24 remain in effect. Although the PCB contamination level in two to three year size class largemouth bass, white catfish and white/-hybrid bass has declined since 1977, there is insufficient evidence to conclude that fish are safe to eat. Before the advisory is lifted, composite (four fish) PCB values should consistently fall below the 1.25 ppm level in order to assure that individual fish do not exceed the safe tolerance limit of 5.0 ppm, or until it can be shown, by individual fish analyses, that PCBs are evenly distributed among same size class fish. This would indicate that no one fish is likely to exceed the safe tolerance limit when the composite PCB value is less than 5.0 ppm.

In addition, there is insufficient information available on the level of PCB contamination of larger fish. Since larger fish have greater PCB burdens, they need to be adequately sampled before considering lifting an advisory based on two to three year old fish. However, this may not be a great concern if considerations are given to the probabilities associated with a fisherman catching and eating a larger, more highly contaminated fish. Based on recent creel survey data from Lake Hartwell, the average size, most frequently caught largemouth bass and catfish are in the two to three year size class (personal communication, Bill Williams). Therefore, it is possible that even-though larger fish may contain PCB levels exceeding 5.0 ppm, there would be a low probability associated with fishermen catching and eating one of these fish.

With respect to the ongoing monitoring program of Lake Hartwell fish for PCB contamination, the following are recommended.

1. Discontinue, as a regular monitoring station, the Andersonville Island (SV-535) location and insert a new station Martin Creek, between Eighteen Mile Creek (SV-532) and Twelve Mile Creek (SV-107). This would give a better delineation of the highly contaminated areas under the present advisory and could help establish new boundaries for an updated advisory in the future. Since the Andersonville Island area has reduced PCB levels, Eighteen Mile Creek should adequately serve as the lower monitoring station in the lake.
2. In additon to collecting two to three year size class white catfish, largemouth bass and white/hybrid bass, collect size classes that will represent older fish. Although the contamination level of PCBs in two to three year size class fish was less in 1981 compared to 1977, it is suspected that PCB levels may continue to rise in this size class fish as they become older. This new sampling scheme should provide the necessary data for lifting or making advisory revisions in the future.
3. If the PCB value of less than 1.25 ppm is not viewed as the safe limit for composites (four fish) but rather the less than 5.0 ppm value, then the collection and PCB analysis of individual fish should be conducted to determine if PCB levels are evenly distributed among fish of the same size class.
4. Focus sampling efforts in the Martin Creek and Eighteen Mile Creek areas of Lake Hartwell where the greatest potential exists for modifications in the advisory. It is evident from

the data that a PCB gradient in fish tissue exists in the lake with concentrations increasing in a direction going up-lake from Eighteen Mile Creek. It is also evident that the gradient is relatively stable. Therefore, conditions will have to improve to acceptable levels in Eighteen Mile Creek before it is possible for similar improvements to occur in Twelve Mile Creek. As conditions improve, sampling locations should then be incrementally moved upwards into the Twelve Mile Creek area until the advisory can be lifted for all of Lake Hartwell.

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